The neutrino physics program of the GADMC:

the DarkNoon concept for 0νββ search

Claudio Savarese

Princeton University

Rare Processes and Precision Frontier Townhall Meeting - Snowmass2021

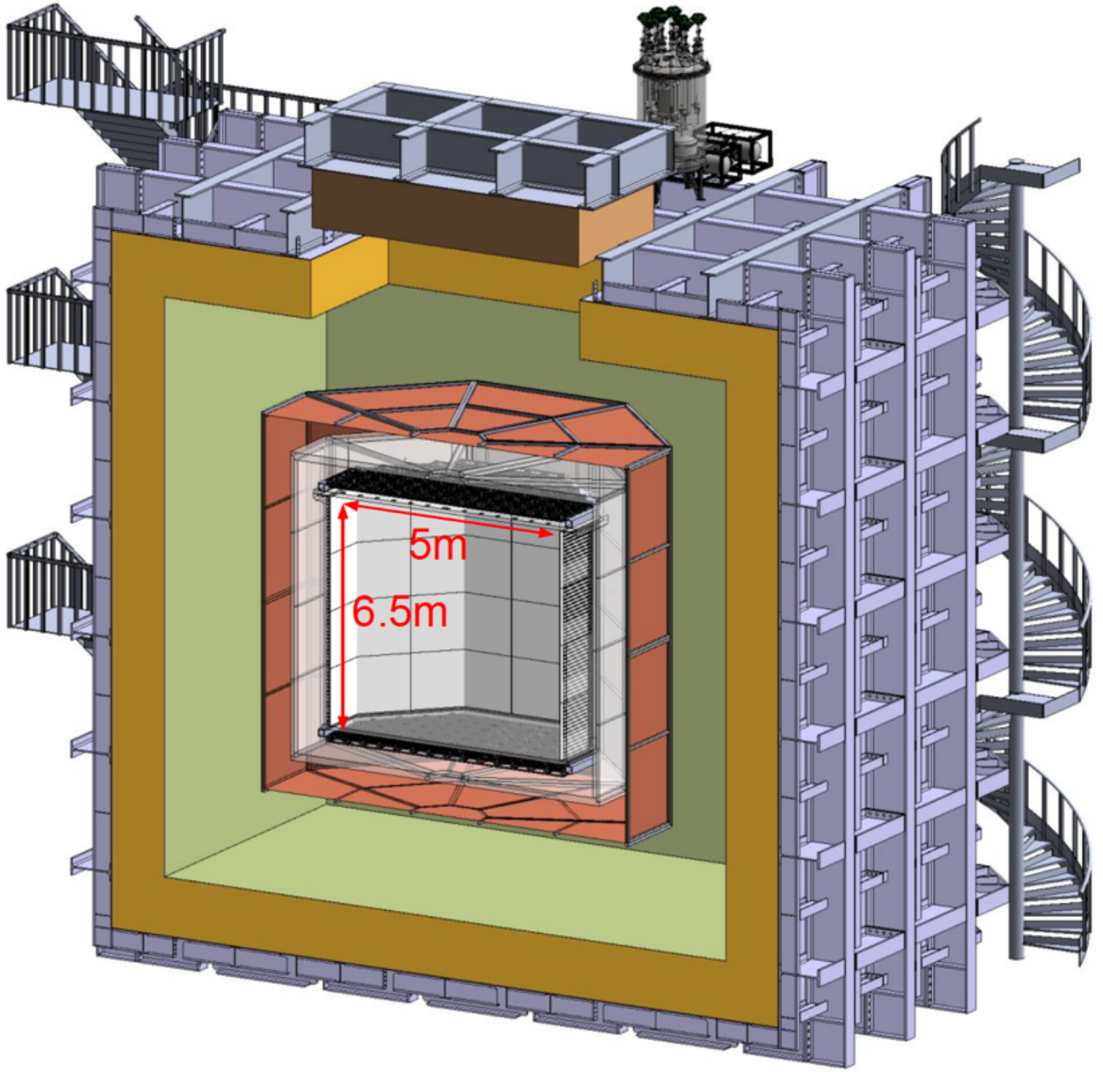
Oct 2nd 2020

DarkNoon detector concept

- Inner detector: dual-phase TPC
- Proto-DUNE membrane cryostat
- AAr in veto, UAr+Xe mixture in TPC

Inner detector:

- Fiducial mass: 50t of ^{136}Xe
- LXe 20% molar fraction in LAr (10.1016/j.fluid.2014.07.020), equivalent to ~41% mass fraction.
- Xe enriched to 90% in ^{136}Xe
- LArXe mixture kept cold near LAr boiling temperature:
  - Slower radon emanation
  - Suppression of SiPMs DCR
- 4π light detection coverage with 0.1ns timing resolution.
- Assumed energy resolution: 0.7% at the ROI due to 4π high PDE SiPM coverage (EXO-200: 1.15±0.02%, nEXO: 1%)



Expected backgrounds

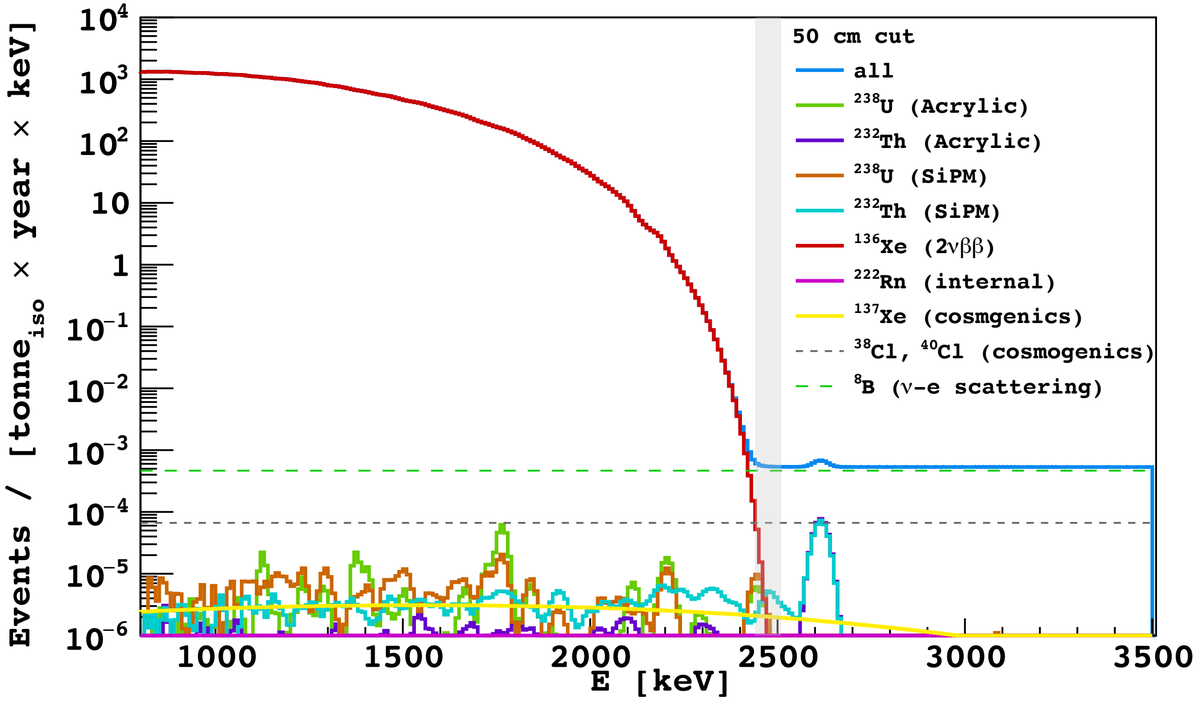
- Expected background rate in the ROI lower than 5E-4 events/tonne/yr/keV, dominated by:
  - ^{8}B ν-e scattering:
    - Xe: 1.8E-4 events/tonne/yr/keV
    - Ar: 2.0E-4 events/tonne/yr/keV
  - 2νββ decay (1.37e-3 events/tonne$_{iso}$/yr in the ROI).

- Radiogenic backgrounds from detector components effectively suppressed by position-based cuts.

- Radon sub-dominant thanks to low temperature of the Ar-Xe mixture and Bi-Po tagging.

- Argon-42 cosmogenic activation (above ground) still to be measured and taken into account.

- A Cherenkov light based cut further reduces surviving single-ionization-track events (not shown in the bkg plot).



Expected backgrounds

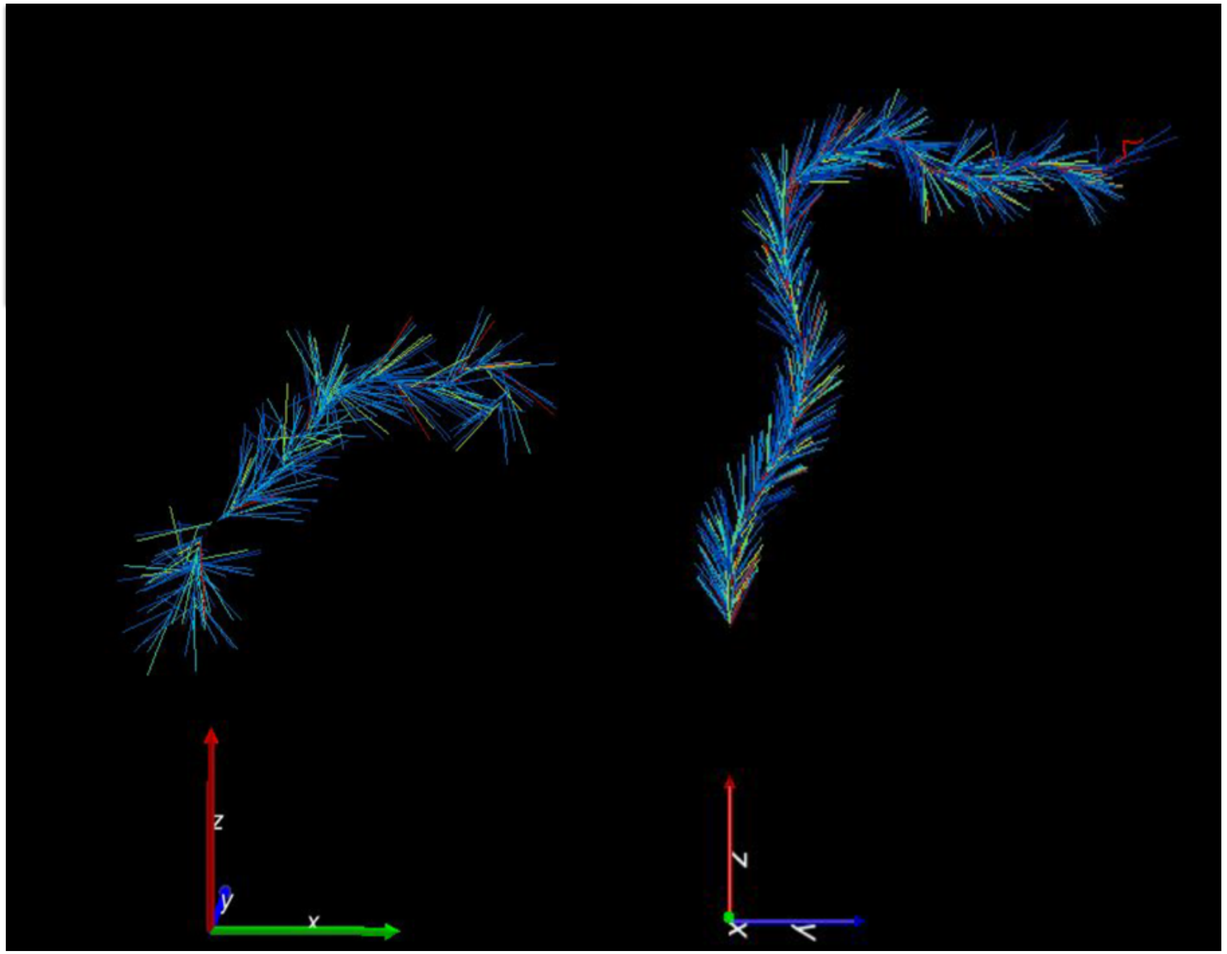
- Expected background rate in the ROI lower than 5E-4 events/tonne/yr/keV, dominated by:
  - ^{8}B ν-e scattering:
    - Xe: 1.8E-4 events/tonne/yr/keV
    - Ar: 2.0E-4 events/tonne/yr/keV
  - 2νββ decay (1.37e-3 events/tonne$_{iso}$/yr in the ROI).

- Radiogenic backgrounds from detector components effectively suppressed by position-based cuts.

- Radon sub-dominant thanks to low temperature of the Ar-Xe mixture and Bi-Po tagging.

- Argon-42 cosmogenic activation still to be measured and taken into account.

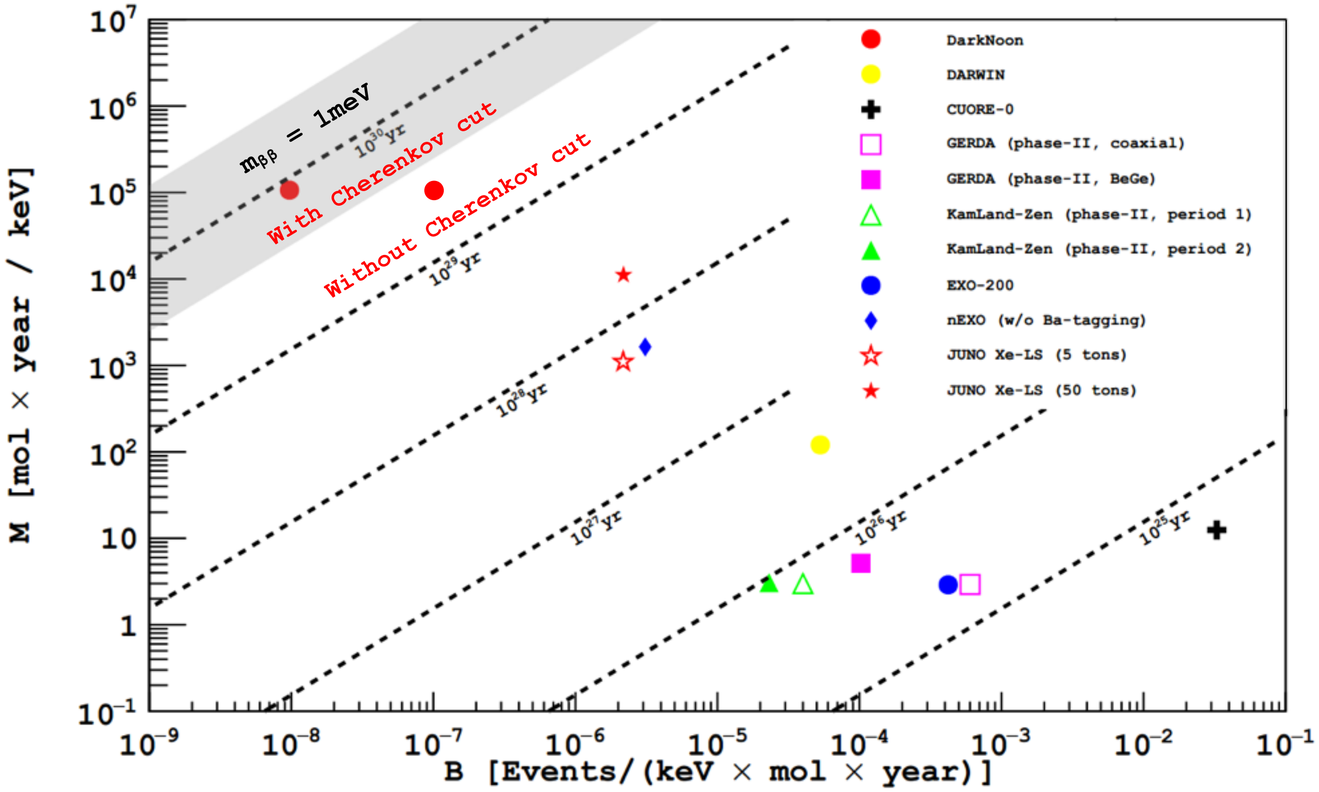
- A Cherenkov light based cut further reduces surviving single-ionization-track events (not shown in the bkg plot).



Simulation of Cherenkov light emission for a DBD decay (left) and for an electron scattering event (right)

Physics reach

- Projections with 1000 t·y exposure (20y)
- Sensitivity up to $T_{1/2} \sim 10^{30}$ years
- Exclusion limits for the effective Majorana mass down to ~1meV (model dependent).



Novel technologies

Idea	Motivation	R&D
• Target: 20% molar fraction mixture of LXe in LAr. Xe enriched to 90% in ^{136}Xe	Mixture temperature near LAr boiling point: • Abatement of Radon emanation/de-gassing. • SiPM dark count rate abatement.	• Develop a cryogenic system that ensures long-term mixture stability. • Cryogenic distillation technique developed for DS-20k to enrich Xe

• Cherenkov light as a mean of background rejection.	• Event classification (1 vs 2 ionization tracks) at a given energy via detection of Cherenkov light from ionizing particles.
	  • intensity proportional to track length.
	  • photons' directionality allows reconstruction of event topology
		• Develop a solid event classification algorithm based on Cherenkov light.

• Detection technology: high efficiency, sub-nanosecond time resolution Silicon Photo Multipliers (SiPMs)	SiPMs' performances • High photon detection efficiency results in a higher energy resolution • Sub-nanosecond time resolution needed for Cherenkov photons identification • Extreme radio-purity	• Develop cleaner cryogenic pre-amplification and read-out electronics. • Improve single photon time resolution.

Themes of broader interest

- LArXe mixture stability
- Xe enrichment through cryogenic distillation on multi-tonne scale
- Argon-42 activity in UAr and activation rate during shipping
- SiPMs development to meet timing and radiopurity requirements
- Cherenkov light cut optimization

Snowmass-2021

- **Physics motivation:** design a DBD experiment with stronger physics reach, up to the normal ordering scale.

- **Timeline:** we're planning on having a dedicated publication for the DarkNoon concept on a timescale of several months. We will also prepare a white paper summarizing DarkNoon physics reach and the other neutrino physics results achievable with the GADMC detectors (supernova physics and solar spectroscopy).

- **Joint efforts:** several R&Ds might be of interest for other experimental groups. These developments are mostly incremental optimizations of already existing solutions and it's reasonable to assume that they could be finalized on a relatively short time scale.

- **Snowmass outcome:** broader community involvement in the R&D and design of next generation DBD detectors.